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Objectively measured physical activity and psychosocial functioning in young children: The GECKO Drenthe cohort

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ABSTRACT

The global trend in inactivity in children may be related to psychosocial problems. We investigated the cross-sectional association between physical activity (PA) levels and psychosocial functioning in 3.4–7.3-year-old children. Children from the Dutch GECKO birth cohort (N = 898; 51.6% boys) had PA levels assessed objectively by accelerometry (ActiGraph GT3X) for at least three days. Linear regression analysis was used for associations with psychosocial functioning (parent report of the Strengths and Difficulties Questionnaire), controlling for gender, age and socio-economic status. Higher total and moderate-to-vigorous PA levels (MVPA) were associated with higher Total Difficulty scores, and sedentary time to lower Total Difficulty scores. More time spent in MVPA was significantly associated to “hyperactivity/inattention” in both boys (Standardized $B_{\text{BOYS}} = 0.192$) and girls ($\text{Std.}B_{\text{GIRLS}} = 0.139$) whereas for the time in sedentary behaviour, a reverse association was found only in boys ($\text{Std.}B_{\text{BOYS}} = -0.230$). In boys only, more time in MVPA ($\text{Std.}B_{\text{BOYS}} = 0.154$) and less time in sedentary behaviour ($\text{Std.}B_{\text{BOYS}} = -0.147$), were significant determinants for ‘behavioural problems’. When using objectively measured PA, parents report more hyperactivity/inattention and behavioural problems in the more active children, and less in the more sedentary children, most clearly for boys. High levels of PA might be an indicator of psychosocial problems in young children.

ARTICLE HISTORY

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KEYWORDS

Motor activity; mental health; child; preschool; accelerometry; questionnaires

Introduction

About 15–26% of children studied in epidemiological research regarding behaviour show notable symptoms of developing psychosocial problems (Fuchs, Klein, Otto, & von Klitzing, 2013). Problems with psychosocial functioning in young children can be defined as behavioural, emotional and social problems which could eventually result in several disorders, like conduct disorder, attention-deficit/hyperactivity disorder (ADHD), major depressive disorder, anxiety disorders or mood disorders in later childhood, adolescence and adulthood (American Psychiatric Association, 2018; Nilsen, Gustavson, Røysamb, Kjeldsen, & Karevold, 2013). In addition, psychosocial problems may affect children’s learning and leisure activities, such as physical activity and participation in sports (Fuchs et al., 2013; Hasson et al., 2017; Lingineni et al., 2012). Nearly half of people display psychosocial disorders at some moment in their lives, with the first onset usually early in life (Kessler et al., 2005). Therefore, early detection of psychosocial problems in young children is important, as it may contribute to the prevention of more severe problems later in life.

In children and youth physical activity (PA) can provide several health benefits, and it has also been associated with psychosocial functioning (Biddle & Asare, 2011; Nijhof et al., 2018; Spruit, Assink, van Vugt, van der Put, & Stams, 2016). It has been shown that physiological effects of PA like norepinephrine and endorphins releases and larger blood supply to the brain can be related to better mental health, as cognitive functioning and mood increases

and stress reduces (Spruit et al., 2016). Therefore, PA could serve as a modifiable factor in order to prevent psychosocial problems in children and youth. However, the global trend of increasing levels of physical inactivity and sedentary behaviour affects children as well, and this may result in more severe psychosocial problems during childhood and adolescence (Ahn & Fedewa, 2011; Mitchell & Steele, 2017). In children, sedentary behaviour can be characterized as TV viewing, computer time, playing video games, i.e., screen time (Hamer, Stamatakis, & Mishra, 2009), and it also includes other activities in sitting or lying posture like playing with toys, drawing or reading books (Downing, Janssen, Cliff, Okely, & Reilly, 2019).

A meta-analysis in children and youth from a wide age range (3–18y, mean age = 12.6, SD = 2.9) found that greater physical activity was related to a lesser likelihood of experiencing detrimental mental health outcomes (Ahn & Fedewa, 2011). Unfortunately, the meta-analysis did not describe the results of children from different age groups, so specific results in young children are not clear yet. A review study on early childhood (children younger than 6 years) reported that no clear conclusions could be drawn regarding relationships between physical activity and sedentary behaviour with psychosocial behaviour (Hinkley et al., 2014). The researchers warranted more studies on PA and sedentary behaviour, captured with objective measures such as accelerometry (Hinkley et al., 2014). Possibly, the lack of objective measures could have contributed to the inconsistent

results, in addition to the relatively small number of studies that were found.

Taken together, identifying the unique relationships between objectively measured levels of PA and sedentary behaviour with psychosocial functioning in young children may support early identification of problems, and thereby early intervention or prevention programs to avoid the development of more serious mental health problems later in life.

The aim of the present study is to investigate the association between objectively measured levels of PA and sedentary behaviour with psychosocial functioning in young children. It is hypothesized that in these young children, high levels of PA are associated with lower scores on psychosocial problems and that high levels of sedentary behaviour are associated with more psychosocial problems.

Methods

Study design and participants

Data was derived from the GECKO Drenthe cohort, a large ongoing prospective population-based birth cohort study aimed to investigate the determinants of health in early life (Figure 1). All mothers from children born from April 2006 to April 2007 and living in Drenthe, a northern province of the Netherlands, were invited to participate during the third trimester of their pregnancy. Detailed information has been published elsewhere (L'Abée, Sauer, Damen, Rake, Cats, & Stolk, 2008). The data in the present study should be considered as cross-sectional. Age at time of data collection was defined by the date difference between moment of measurement and birth date (Sijtsma, Koller, Sauer, & Corpeleijn, 2015). Data on physical activity were collected between May 2011 and October 2013; the children were on average 5.6 years of age (5th – 95th age percentile: 4.3–6.9). Data on psychosocial functioning were collected between January 2011 and September 2013; the children were on average 5.8 years of

age (5th – 95th age percentile: 5.3–6.3). The average age difference was 0.2 ± 0.8 months, and a 95% confidence interval of -1.3 to 1.6 years indicated that in 5% of children, psychosocial functioning was measured 1.6 years after the physical activity assessment and that in 5% of children psychosocial functioning was measured 1.3 years before the PA assessment.

The study was approved by the Medical Ethics Committee of the University Medical Center Groningen and performed in accordance with the Declaration of Helsinki and all parents gave informed consent.

Measurements

Height, weight, and socio-economic status

At the age of six years, height and weight were measured by trained nurses from the municipal health services. Height and weight were measured by trained Youth Health Care nurses according to a standardized protocol. Weight was measured in light clothing using an electronic scale with digital reading and recorded to the nearest 0.1 kg. Height was assessed using a stadiometer and recorded to the nearest 0.1 cm. Socio-economic status (SES) was assessed by a deprivation score based on postal code. The score has been provided by the Dutch Social and Cultural Planning Office of the Dutch government and is based on mean income, education level and unemployment rates (Dutch Social and Cultural Planning Office, 2018).

Psychosocial functioning

Psychosocial problems were assessed with the Dutch version of the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997). Parents completed the questionnaires, which were collected and processed by the municipal health services. The SDQ is a short questionnaire (25 items), on positive attributes of the child as well as

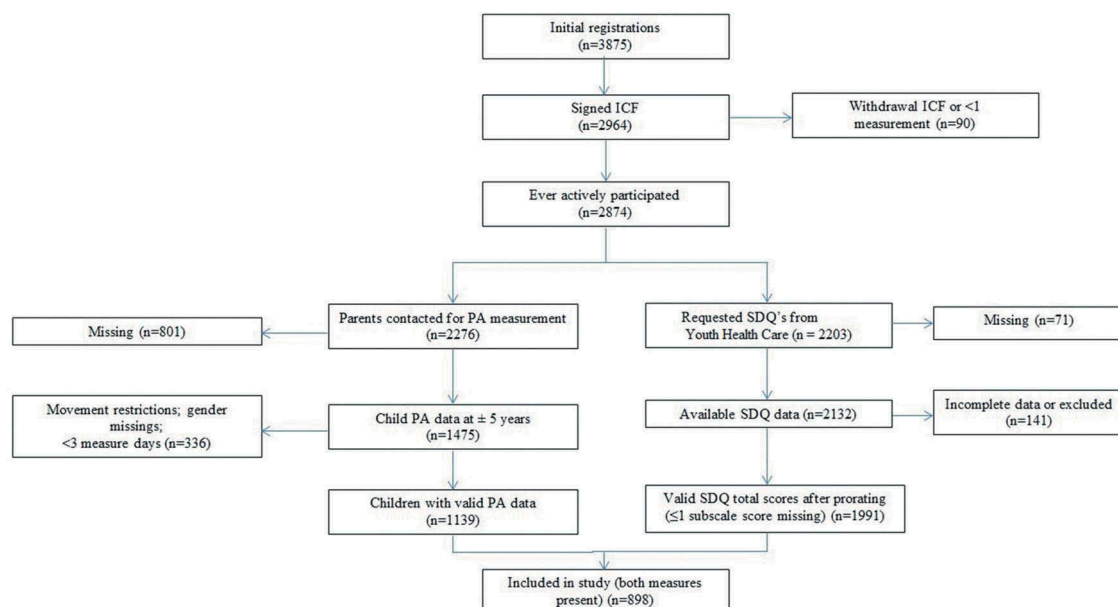


Figure 1. Flowchart of subject recruitment.

difficulties. It has good acceptability by respondents (Goodman, 2001). The items are grouped into five subscales, “prosocial behaviour” (i.e., being helpful), ‘emotional problems’ (i.e., unhappiness), ‘behavioural problems’ (i.e., conduct problems), ‘peer problems’ (i.e., friendless) and “hyperactivity/inattention” (i.e., restless). Every scale consists of five items that are equally weighted and scored on a 3-point scale from “not true”, “somewhat true” to “certainly true”. The prosocial scale is reverse scored and excluded from the total difficulties score (Goodman, 2001). When no more than one of the four subscale scores was missing the Total Difficulties score was prorated by substituting the mean. High scores indicate high symptom levels. The SDQ is considered to be a valid and reliable instrument for evaluating psychosocial functioning in children and youth. The proposed five-factor structure has a satisfactory fit in children and adolescents (aged 3–16 years) (Björnsdotter, Enebrink, & Ghaderi, 2013; Goodman, 2001; Muris, Meesters, & van Den Berg, 2003). The internal consistency (Cronbach’s alpha) of the SDQ parent report is moderate to high, varying between 0.50 and 0.78 for the subscales and around 0.80 for the Total Difficulties in children and adolescents. Subscales with the lowest scores are ‘peer problems’, ‘emotional problems’ and ‘behavioural problems’ (Björnsdotter et al., 2013; Goodman, 2001; Theunissen, Vogels, de Wolff, Crone, & Reijneveld, 2015). Concurrent validity with the Child Behavior Checklist (CBCL) is moderate to high, around 0.70 (Pearson correlation) (Muris et al., 2003; Theunissen et al., 2015). Retest stability of the SDQ parent report is satisfactory after two months (correlations between 0.75 and 0.91) (Muris et al., 2003) and after four to six months (correlations between 0.61 and 0.72) (Goodman, 2001). In nearly all studies mentioned earlier regarding psychometric properties of the SDQ, representative community samples were used.

Physical activity

PA in children was assessed using the ActiGraph GT3X (ActiGraph, Pensacola, FL). Parents of all children participating in the GECKO Drenthe birth cohort study were contacted to collect PA data of their child. Parents were instructed to let their child wear the ActiGraph on the iliac crest with an elastic belt on the right hip for four days, of which at least one weekend day, during all waking hours except while bathing or swimming. For valid measurements, wearing time had to be at least 600 min/day for at least three days, regardless whether these were week or weekend days. Non-wearing time of the ActiGraph was classified as a minimum length of 90 min without any observed counts. Cut-points were used to calculate time spent in sedentary vs light (240 counts per minute), light vs moderate PA (2120 counts per minute), and moderate vs vigorous PA (4450 counts per minute) (Butte et al., 2014). An epoch time of 15 s was used for analyses. Data were collected using a frequency of 30 Hz. All children with wearing time ≥ 840 min/day (14 h/day) were checked manually for sleeping time. Sending the accelerometers by post sometimes resulted in a valid wearing day (>10 h/day). These postmen days were identified by low light activity (≤ 100 min/day) and deleted (Sijtsma et al., 2015).

Statistical analysis

Values are presented as numbers (%), means (\pm standard deviations) and range (minimum–maximum). Skewed or ordinal variables are presented as median (25th and 75th percentile) and were ln-transformed for linear regression analysis. SES scores were used as a continuous variable in the analyses but shown in Tables as three categories: scores below -1 were considered as low SES and scores above $+1$ as high SES. The remaining scores were considered as “middle SES”. Differences in gender were compared using non-parametric tests (Mann–Whitney U) because most PA variables were not normally distributed. The associations between PA and psychosocial functioning were investigated using Spearman correlations (r_s). When associations were significant, linear regression analyses were conducted with adjustment for age at psychosocial functioning assessment, age at PA assessment, gender and SES. If necessary, variables were ln-transformed. To investigate gender differences, interaction models for gender were studied. Standardized beta coefficients and unstandardized beta coefficients with 95% confidence intervals were shown for regression analyses. An alpha level lower than 0.05 was considered significant. Statistical analyses were conducted using IBM SPSS Statistics 23 for Windows (SPSS Inc., Chicago, IL).

Results

Descriptives

Of the 2875 children that ever participated, 2203 were seen by Youth Health Care nurses at kindergarten. Of these, 2132 parents filled in the SDQ questionnaires (97%), of which 1991 were valid. From the 1475 children with PA data, 1139 were valid. In total 898 children with valid PA and SDQ data were included in the data analysis (see Figure 1). The age range of the children was between 3.4 and 7.3 years old during the measurements (Table 1). About half (51.6%) of the children were boys, and boys were more active than girls. There was no significant difference in age, BMI and SES between boys and girls. Furthermore, boys had higher scores on SDQ Total Difficulties, and subscores “hyperactivity/inattention” and ‘behavioural problems’. In the study population, an abnormal Total Difficulties score (20–40) was found in 1.3% of the sample and 1.3% was considered borderline (17–19). In boys, 2.6% had an abnormal Total Difficulties score and 1.3% had a borderline score, whereas in girls 1.4% scored borderline, and no abnormal scores were found. Details are shown in Table 1.

Associations between PA levels and psychosocial functioning

The correlations between PA and psychosocial functioning are presented in Table 2. Higher PA levels were associated with higher scores for Total Difficulties and the subscales “hyperactivity/inattention” and ‘behavioural problems’, whereas time spent in sedentary behaviour was associated with lower scores for Total Difficulties and “hyperactivity/inattention”. Since the associations were present for moderate PA, vigorous PA as well as for MVPA, analyses were continued with MVPA only.

Table 1. Descriptive characteristics of the study population.

GENERAL	Total			Boys			Girls		
	N		Min – max	N		Min – max	N		Min – max
Age at PA measurement (years)	898	5.6 ± 0.8	3.4–7.3	463	5.6 ± 0.8	3.4–7.3	435	5.6 ± 0.8	3.6–7.3
Age at SDQ (years)	898	5.8 ± 0.3	4.8–6.8	463	5.8 ± 0.3	4.8–6.8	435	5.8 ± 0.3	4.9–6.8
BMI (kg/m ²)	864	15.9 ± 1.3	13.3–22.4	446	15.9 ± 1.2	13.3–20.5	418	16.0 ± 1.4	13.2–22.4
SES	882			451			431		
Low		197 (22.3)			105 (23.3)			92 (21.3)	
Middle		566 (64.2)			287 (63.6)			279 (64.7)	
High		119 (13.5)			59 (13.1)			60 (13.9)	
PHYSICAL ACTIVITY									
Total CPM (counts) ^a	898	805 ± 220	338–2033	463	840 ± 234	397–2033	435	767 ± 198	338–1647
Sedentary time (min/day) ^a	898	373 ± 57	221–630	463	367 ± 57	243–630	435	378 ± 56	221–554
Light PA(min/day)	898	265 ± 38	155–380	463	265 ± 37	170–361	435	265 ± 39.1	155–380
Moderate PA (min/day) ^a	898	43.8 (35.6–54.7)	10–117	463	47.3 (39.5–60.1)	17–117	435	40.0 (31.4–49.3)	10–88
Vigorous PA (min/day) ^a	898	17.0 (11.4–24.5)	2–97	463	19.2 (12.9–27.0)	2–97	435	14.7 (10.2–22.2)	2–65
MVPA (min/day) ^a	898	61.4 (47.9–80.1)	12–183	463	68.3 (53.3–85.9)	20–183	435	54.8 (42.9–71.2)	12–129
SDQ									
Total Difficulties ^a	898	5 (2–7)	0–23	463	5 (3–8)	0–23	435	4 (2–7)	0–19
Hyperactivity/inattention ^a	897	2 (1–4)	0–10	462	3 (1–5)	0–10	435	1 (0–3)	0–10
Peer problems	888	0 (0–1)	0–7	459	0 (0–1)	0–7	429	0 (0–1)	0–5
Emotional problems	895	1 (0–2)	0–8	462	1 (0–2)	0–8	433	1 (0–2)	0–7
Behavioral problems ^a	891	0 (0–2)	0–8	458	1 (0–2)	0–8	433	0 (0–1)	0–7
Prosocial behavior ^{a, b}	892	9 (8–10)	1–10	458	9 (7–10)	1–10	434	9 (8–10)	2–10

^a $p < 0.05$ for gender, ^b the prosocial scale is not included in the total score; and high scores are positive. BMI, Body Mass Index; CPM, counts per minute; MVPA, moderate-to-vigorous physical activity; PA, physical activity; SDQ, Strengths and Difficulties Questionnaire; SES: Socio-economic Status (deprivation score). Data are presented as mean ± SD, N (%) or median (25th – 75th percentile).

Table 2. Correlations between physical activity and psychosocial functioning in young children (n = 898).

	Total Difficulties	Hyperactivity/inattention	Peer problems	Emotional problems	Behavioral problems	Prosocial behavior ^a
Total CPM	0.080*	0.140**	−0.025	−0.040	0.054	0.000
Sedentary behavior	−0.117**	−0.179 **	0.022	−0.003	−0.059	−0.025
Light PA	0.038	0.100**	−0.025	−0.017	0.000	0.057
Moderate PA	0.149**	0.224**	−0.014	−0.042	0.117**	−0.032
Vigorous PA	0.102*	0.170**	−0.018	−0.043	0.076*	−0.063
MVPA	0.141**	0.218**	−0.014	−0.047	0.107**	−0.049

Spearman correlation coefficients and p-values (between brackets) are given. ^a the prosocial scale is not included in the total score; and high scores are positive.

* $p < 0.05$ ** $p < 0.01$ CPM, Counts per minute; MVPA, moderate to vigorous physical activity; PA, physical activity

Since boys and girls differed both in PA levels as well as SDQ scores, correlations were investigated for boys and girls separately. In boys, Total counts per minute (CPM) was significantly associated with Total Difficulties ($r_s = 0.115$, $p = 0.013$) and MVPA was positively associated with Total Difficulties ($r_s = 0.148$, $p = 0.001$). Time in sedentary behaviour was inversely associated with Total Difficulties ($r_s = -0.169$, $p = 0.000$). The association between Total CPM and Total difficulties was explained by association with subscale “hyperactivity/inattention” ($r_s = 0.154$, $p = 0.001$) and subscale ‘behavioural problems’ ($r_s = 0.101$, $p = 0.030$).

The association between Total CPM and “hyperactivity/inattention” in boys could be explained by an inverse association of sedentary time with “hyperactivity/inattention” ($r_s = -0.233$, $p = 0.000$) and a positive association of LPA with “hyperactivity/inattention” ($r_s = 0.123$, $p = 0.008$) and MVPA with “hyperactivity/inattention” ($r_s = 0.194$, $p = 0.000$). After adjustment for exact age and SES (see Table 3), these associations remained virtually unchanged in boys (sedentary time: Std B = 0.230; LPA: 0.136; MVPA: 0.192). The association between Total CPM and ‘behavioural problems’ in boys could be explained by time in sedentary behaviour ($r_s = -0.132$, $p = 0.005$) and MVPA ($r_s = 0.157$, $p = 0.001$) but not by time in LPA. The adjustments for exact age and SES (see Table 4) did not

substantially change these findings (sedentary time: Std B = 0.147; MVPA: 0.154).

In girls, only MVPA was associated with “hyperactivity/inattention” ($r_s = 0.139$, $p = 0.004$), whereas a trend was seen for time in sedentary behaviour and “hyperactivity/inattention” ($r_s = -0.091$, $p = 0.059$). The adjustment for exact age and SES (see Table 3) did not change the association for MVPA (Std B 0.139) or sedentary behaviour and “hyperactivity/inattention” (Std B = 0.094, $p = 0.057$).

Discussion

The aim of the present study was to investigate the association between objectively measured levels of PA and sedentary behaviour with psychosocial functioning in young children. The study showed that parents from highly active children reported higher scores on psychosocial problems. In contrast, parents from children who were more sedentary reported fewer psychosocial problems.

The present study showed that more PA was associated with more hyperactivity/inattention and behavioural problems in young children, in particular in boys. Our results were not in accordance with a meta-analysis in children and youth from a wide age range (3–18 years) showing a positive association

Table 3. Regression analysis for the PA levels and psychosocial functioning “hyperactivity/inattention” in young children for the total population and stratified by gender.

Hyperactivity/inattention (ln)	Total			Boys			Girls		
	Std. B	B	95% CI of B	Std. B	B	95% CI of B	Std. B	B	95% CI of B
<i>Sedentary time</i>									
Model 1: SED	-0.170	-0.002	(-0.003;-0.001)	-0.206	-0.002	(-0.004;-0.001)	-0.099	-0.001	(-0.002;0.000)
Model 2: SED	-0.165	-0.002	(-0.003;-0.001)	-0.230	-0.003	(-0.004;-0.002)	-0.094	-0.001	(-0.002;0.000)
Model 3: SED	-0.316	-0.004	(-0.006;-0.001)	-	-	-	-	-	-
SED ×Gender	0.385	0.001	(0.000;0.003)	-	-	-	-	-	-
<i>Light physical activity</i>									
Model 1: LPA	0.083	0.002	(0.000;0.003)	0.108	0.002	(0.000;0.004)	0.065	0.001	(-0.001;0.003)
Model 2: LPA	0.097	0.002	(0.001;0.003)	0.136	0.002	(0.001;0.004)	0.060	0.001	(-0.001;0.003)
Model 3: LPA	0.187	0.003	(0.000;0.007)	-	-	-	-	-	-
LPA ×Gender	-0.228	-0.001	(-0.003;0.001)	-	-	-	-	-	-
<i>Moderate-to-vigorous physical activity (ln)</i>									
Model 1: MVPA	0.217	0.397	(0.280;0.515)	0.196	0.367	(0.198;0.535)	0.136	0.252	(0.079;0.424)
Model 2: MVPA	0.171	0.312	(0.190;0.433)	0.192	0.358	(0.187;0.530)	0.139	0.257	(0.084;0.430)
Model 3: MVPA	0.242	0.442	(0.057;0.826)	-	-	-	-	-	-
MVPA ×Gender	-0.243	-0.086	(-0.329;0.156)	-	-	-	-	-	-

Model 1, crude; model 2, adjusted for SES, age and gender (if applicable), model 3, adjusted for SES, age, gender and interaction with gender. Ln, ln transformation. SED, sedentary time, LPA, light physical activity, MVPA, moderate-to-vigorous activity

Table 4. Regression analysis for the PA levels and psychosocial functioning ‘behavioural problems’ in young children for the total population and stratified by gender.

Behavioral problems (ln)	Total			Boys			Girls		
	Std. B	B	95% CI	Std. B	B	95% CI	Std. B	B	95% CI
<i>Sedentary time</i>									
Model 1: SED	-0.073	-0.001	(-0.001;0.000)	-0.140	-0.001	(-0.002;0.000)	0.034	0.000	(-0.001;0.001)
Model 2: SED	-0.055	-0.001	(-0.001;0.000)	-0.147	-0.001	(-0.002;-0.001)	0.055	0.000	(0.000;0.001)
Model 3: SED	-0.308	-0.003	(-0.005;-0.001)	-	-	-	-	-	-
SED ×Gender	0.643	0.002	(0.000;0.003)	-	-	-	-	-	-
<i>Light physical activity</i>									
Model 1: LPA	-0.007	0.000	(-0.001;0.001)	0.065	0.001	(0.000;0.002)	-0.085	-0.001	(-0.002;0.000)
Model 2: LPA	-0.015	0.000	(-0.001;0.001)	0.068	0.001	(0.000;0.003)	-0.105	-0.001	(-0.003;0.000)
Model 3: LPA	0.196	0.003	(0.000;0.006)	-	-	-	-	-	-
LPA ×Gender	-0.533	-0.002	(-0.004;0.000)	-	-	-	-	-	-
<i>Moderate-to-vigorous physical activity (ln)</i>									
Model 1: MVPA	0.109	0.155	(0.062;0.248)	0.145	0.225	(0.084;0.366)	-0.012	-0.016	(-0.147;0.115)
Model 2: MVPA	0.073	0.103	(0.006;0.200)	0.154	0.236	(0.092;0.380)	-0.022	-0.031	(-0.162;0.100)
Model 3: MVPA	0.350	0.496	(0.189;0.803)	-	-	-	-	-	-
MVPA ×Gender	-0.945	-0.261	(-0.454;-0.067)	-	-	-	-	-	-

Model 1, crude; model 2, adjusted for SES, age and gender (if applicable), model 3, adjusted for SES, age, gender and interaction with gender. Ln, ln transformation. SED, sedentary time, LPA, light physical activity, MVPA, moderate-to-vigorous activity

between PA and psychosocial well-being (Ahn & Fedewa, 2011). The contrasting results from our study with those from Ahn and Fedewa (2011) could be related to the different activity patterns in young children relative to older children. Older children are more engaged in organized activities, like organized sports, whereas young children are more engaged in unorganized activities, like playing. It has been shown that physical activity patterns in younger children are more intermittent than in older children (Bailey et al., 1995; Colley, Harvey, Grattan, & Adamo, 2014). Furthermore, the increased MVPA in our study population of young children could be partly an expression of underlying behavioural problems. The intrinsic need to be active can be strong in children and increased MVPA could be perceived by parents and others as “restless behaviour”. An advantage in our study is that PA was measured using an objective device, so children classified as hyperactive by their parents showed, in reality, higher activity levels than other children, it was not just their perception.

Our results add to the lack of evidence that was shown in a review regarding the relationship between PA and sedentary behaviour with psychosocial functioning in young children (<6 years) (Hinkley et al., 2014). A possible explanation for the contrasting results with Hinkley et al. (2014) could be the lack of objectively measured physical activity in the studies that were reviewed. Only one of the 19 studies used accelerometry for measuring PA and sedentary behaviour (Ebenegger et al., 2012). Although in their study measurements of psychosocial problems were restricted to the subscale “hyperactivity/inattention”, and boys and girls were not considered separately, it is interesting to mention that we also found a negative association between sedentary behaviour and hyperactivity/inattention in our total sample, but only in boys. In addition, our study extends evidence from Ebenegger et al. (2012) to the subscale ‘behavioural problems’, but again the negative

association was only demonstrated in boys. Sedentary behaviour might be experienced as calm behaviour when children are sitting and watch television for example. Finally, our results confirmed results from Ebenegger et al. (2012) that more MVPA was associated with higher scores on hyperactivity/inattention, and we added similar results on behavioural problems, but only in boys. In future studies on young children, the use of accelerometry and identification of different subdomains of psychosocial functioning is warranted.

An interesting finding was that the association between PA levels and psychosocial functioning was stronger in boys compared to girls. These results are in contradiction with those from the meta-analysis from Biddle and Asare (2011), showing no differential effects for gender in cross-sectional studies. Possibly, in our study, the SDQ was more suitable for investigating psychosocial problems in boys compared to girls, reflecting boys' behaviour better than that of girls. The finding that boys had higher scores on the SDQ total and the subscales extends results from previous research in older children and adolescents (Mohammadi et al., 2014; Muris et al., 2003) to younger children. Similar, the finding that boys were more physically active than girls are in agreement with earlier studies in preschoolers (aged 2–5 years) using objective measures (Hinkley, Crawford, Salmon, Okely, & Hesketh, 2008; Jackson et al., 2003; Pate, Pfeiffer, Trost, Ziegler, & Dowda, 2004). Based on the gender differences found in our study, boys are in particular an interesting subgroup for PA-interventions aimed at improving mental health. Future studies should keep in mind that differential effects might exist in young children. In addition, it would be interesting to study possible mechanisms behind the differences between boys and girls. In summary, our study provides evidence that in young children, stronger relations exist in boys than in girls between levels of PA and sedentary behaviour with psychosocial outcomes.

The findings in our study implicate that high MVPA might be an indicator of psychosocial problems in young children. One could argue that objectively measuring PA can help to identify children who are hyperactive. In that respect, measuring PA as a supportive tool could be relevant for diagnostic and screening purposes for early identification of psychosocial problems. It may even be helpful for parental support to analyse which parts of the day these children are hyperactive in order to improve coping strategies. Interestingly, this association seemed to cover the whole range of levels of activity, and not just the extremely active children. Thus, it was also found that boys with higher levels of sedentary behaviour are perceived as having very few difficulties in the psychosocial domain. Because of the cross-sectional nature of the present study, it is not possible to draw conclusions about the causality of this relation. In addition, it must be noted that sedentary behaviour is associated with negative health effects in children (Stiglic & Viner, 2019; Wu et al., 2017).

Important strengths of this study were the representativeness of the study population with regard to SES, the young age, the large sample size and the objectively measured PA levels of the children. Objective measures of PA are hardly performed in young children, as most previous research used questionnaires for measuring PA. However, often in PA

questionnaires, people tend to overestimate MVPA and underestimate sedentary behaviour (Reilly et al., 2008). Furthermore, PA levels of young children are highly variable (Pate et al., 2004) which makes it unlikely that parents can make reliable estimates. In addition, parents who perceive very active behaviour as problematic may be inclined to over report this type of behaviour.

A limitation of this study is that the associations were based on cross-sectional data, which prevents us from drawing conclusions about causal relationships. With regard to the SDQ, there is a possibility of report bias. In this study, we used parent reports, but no additional teacher reports. Furthermore, although the validity of the SDQ is considered to be moderate to high (Goodman, 2001; Muris et al., 2003), the 'behavioural problems' subscale was one of the scales with low-moderate internal consistency (Björnsdottir et al., 2013; Goodman, 2001; Theunissen et al., 2015). A possible explanation for this could be that questions of this subscale reflected better boys' behaviour than that of girls. Another point is that using the Actigraph data, we cannot discern between moderate to a vigorous activity like running during playing in the playground and "hyperactivity" as inappropriate high activity given the situation.

Our study infers some practical implications. Firstly, spontaneous higher levels of PA are related to higher levels of psychosocial problems as reported by parents, which in turn are expected to lead to long-term lower physical activity levels or lower sports participation. Secondly, associations between PA levels and psychosocial functioning are different for boys and girls, and associations in young children compared to those in older children or adults are not the same. These differences must be taken into account when PA-interventions are developed. And finally, objective measurements of PA may be helpful to identify children with hyperactivity/inattention and behavioural problems at young age.

In conclusion, when using objectively measured PA, parents report more hyperactivity/inattention and behavioural problems in the more active children, and less in the more sedentary children, most clearly for boys. Furthermore, very high PA might be an indicator of less psychosocial functioning in young children. These findings could be helpful in screening and diagnostics. Longitudinal research is desired to further investigate the association between PA and psychosocial functioning in young children.

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